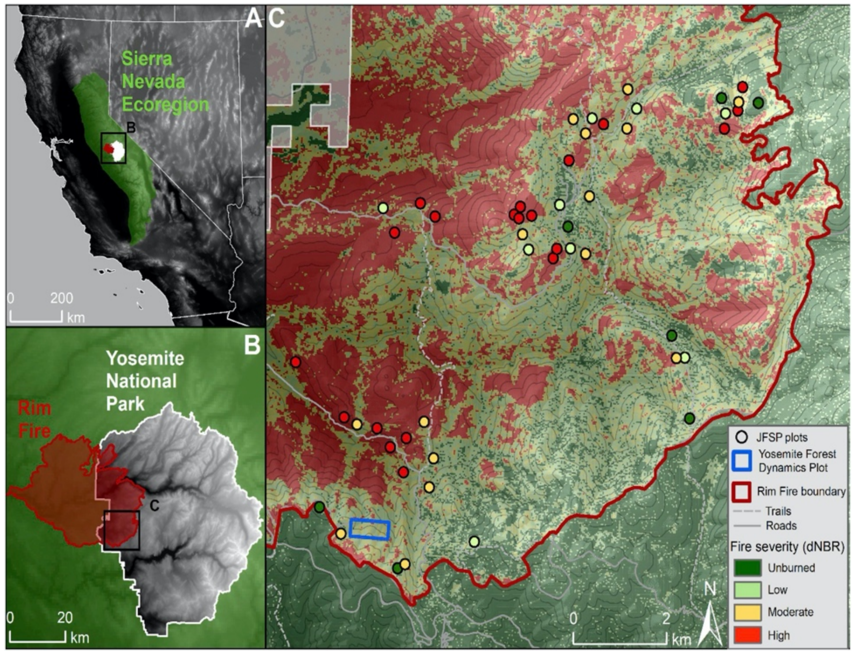
Supporting resource management with permanent research plots

Lessons from the Rim Fire

The Yosemite Forest Dynamics Plot (YFDP) is a 63-acre (25.6 ha) plot in the Rockefeller Grove of sugar pines in Yosemite National Park. In 2009-2010, all 34,458 live trees within the plot were tagged, measured, and mapped.

Each tree and snag has been re-visited every year since, and newly dead trees are examined to identify the multiple factors associated with death. The plot burned on Sept. 1st and 2nd, 2013, in the backfire set to control the spread of the Rim Fire. We are continuing to conduct annual mortality surveys to measure delayed fire effects, and in 2017 we installed 54 smaller (0.6-ac, 0.25 ha) auxiliary plots to capture a broader extent and range of severity of the Rim Fire in Yosemite. The Rim Fire provided an opportunity to examine fire heterogeneity, evaluate commonly used fuel and fire models, and to contribute to our fundamental understanding of fire ecology in Western forests.[1]



Location of the YFDP and auxiliary Joint Fire Science Program study sites in the Western Sierra Nevada (A) within Yosemite National Park (B, C). The background (C) shows Landsat-derived fire severity.

Modeling Fire-Related Tree Mortality [2,3]

First-order fire effects models (FOFEM) are intended to predict the immediate consequences of fire. **We found that these models systematically under-predicted mortality for large-diameter conifers** (sugar pine, white fir, and incense cedar), likely due to model development using datasets of smaller trees. Conversely, the same models **over-predicted mortality for hardwood species** (California black oak and Pacific dogwood), whose resprouting tendencies are critical in shaping the landscape post-fire.[2]

Post-fire tree mortality is a complex process; whether or not a tree survives fire depends on a variety of factors across a range of scales. These factors include fire intensity, tree stature, species traits (e.g., bark thickness), and post-fire stresses like competition and insects. **Resistance to one can indicate susceptibility to another.**[3]

Climate has both direct and indirect effects on fire severity, and the timing of the Rim Fire during the severe drought of 2012-2015 may have contributed to the systematic error that we observed in FOFEM predictions. ***Our results indicate that models developed under past climactic conditions may not be sufficient to accurately predict fire-related mortality for fires that burn under hotter and drier climates***.[2]

Unburned patches [4]

Fire refugia are critical components of post-fire landscapes. **Unburned patches of different sizes create critical habitat and offer sources for natural forest regrowth.** We found that understory species richness and sapling survival was higher, even in very small (~1 m^2) refugia. These unburned **patches introduce variability in fire effects and post-fire species composition**, making them unique and important components of forests following fire.

Prescribed burns that leave patches intact and unburned allow for natural re-establishment post fire.

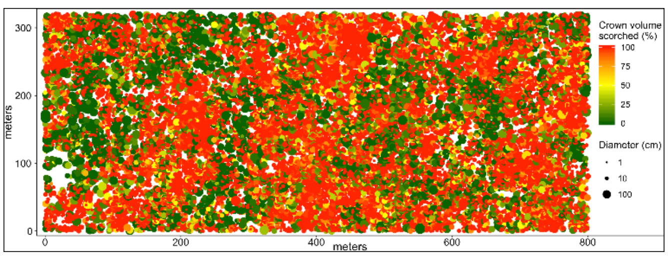
The YFDP in May 2013 (top) and May 2016 (bottom). Photos by T. Furniss

Remote Sensing of Fire Effects [5]

Remote sensing allows for new ways of studying fire effects, beyond boots on the ground. Satellite imagery can best detect mortality of stems ≥50 cm diameter, an intuitive result considering that these trees dominate the satellite's view of the forest. Mortality of trees ≥100 cm was less detectible, possibly because their lower relative abundance makes them a less prominent component of resulting imagery. **Mortality of trees <10 cm was not detectable with any Landsat-derived index**, simply because they are not present in the camera's view.

There was a considerable amount of uncertainty in severity maps. **We estimate that the range in mortality may be at least 20% *higher or lower* than expected for the majority of the fire footprint**. While some of this uncertainty will average out at large scales, **it represents actual heterogeneity that is undetectable based on satellite-derived severity maps alone**.

Remotely sensed data should be ground-truthed.



Stem map of the 34,458 pre-fire trees within the Yosemite Forest Dynamics Plot, colored by percent crown scorched during the 2013 Rim Fire. Patterns of lower and higher canopy scorch primarily indicate landscape features (i.e., vernal streams, swales, and ridgetops). However, nested within those patterns are individual trees and clumps with different levels of crown scorch, showing the importance of fire behavior and local tree neighborhoods to fire effects. Fire effects at the scale of trees are much more heterogeneous than at the Landsat pixel scale.

Post-fire morel mushroom abundance [6]

Morel mushroom abundance in recently-burned forests had never been studied in Sierra Nevada mixed-conifer forests before the Rim Fire. Morels were abundant one-year post-fire and are generally found clumped at scales up to 7m.

The current morel mushroom harvest rules (one pint per person per day) are conservative relative to annual production and recreational demand. ***Our study suggests that Yosemite managers could re-evaluate recreational collection limits without compromising morel populations***, especially in years following large fires.

Surface fuel dynamics [7]

Old growth forests that have been subjected to fire suppression have high levels of surface fuels. **FOFEM over-predicted consumption of fine fuels, primarily because it did not capture the heterogeneity in fire effects that let some surface fuels remain.** FOFEM systematically under-predicted consumption of large woody fuels, possibly because it was not calibrated with fuels larger than 30 cm in diameter.

In forests with big trees, **large-diameter logs are a significant source of fuels both before and after fire**. Improving our understanding of post-fire large wood dynamics is a central focus of the ongoing research in the YFDP.

Fire-suppressed, lower-montane forests ***will require multiple fires to return to low surface fuel loadings***.

The California Rim Fire was characteristic of the new fire regime we can expect for the region. As climate becomes hotter and drier, these larger, more severe fires will become the norm.

In designing landscape restoration treatments, we should use models and remotely sensed data cautiously, because they may obscure heterogeneity of fire effects that *is likely at least partially responsible for the biodiversity of the Sierra Nevada.*

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